Ionizing radiation

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Radioactivity

a mechanism whereby an unstable nucleus rearranges itself to become more stable. The process often involves the ejection of charged particles from the atomic nuclei. This ejection of particles (beta or alpha) is often accompanied by the emission of gamma rays from the nucleus or x-rays from the atom’s electron shells.

- Alpha particles, beta particles, gamma rays and x-rays are types of ionizing radiation. When they interact with other atoms, they have enough energy to cause ionization of these atoms.
- beta and alpha particles ↘ low penetration through skin
  - only toxic after ingestion

gamma rays and x-rays ↘ high penetration
- hazardous external exposure

Management

- • Contaminated victims are patients with radioactive material on them or inside their bodies.
- •Contaminated patients require care in handling to effectively remove and control the contamination (need decontamination).
- • Irradiated victims are patients who have only been exposed to the radiation from a radioactive source or a machine, such as an x-ray machine, are not contaminated and do not pose any radiation contamination or exposure potential for hospital personnel.
- •Radiation safety precautions are not needed for patients who have only been exposed and are not contaminated.

Mechanism of toxicity

- Large Dose of ionizing radiation hydrolyzes water in cell and produces highly reactive free hydroxyl radicals that damage the cell.
- Most sensitive cells are bone marrow, skin, GI

And pulmonary.

Damage of cell DNA leads to failure of replication or mutation

Types of Ionizing Radiation

- • **Alpha particles.** Alpha particles are ejected from the nuclei of some very heavy radioactive atoms (atomic number > 83). An alpha particle is composed of two neutrons and two protons. If an alpha emitting radioactive material gets inside the body through inhalation, ingestion, or through a wound, the emitted alpha particles can cause ionization that results in damage to tissue.
- •**Beta particles.** A beta particle is an electron ejected from the nucleus of a radioactive atom. Some beta radiation can penetrate human skin to the layer where new skin cells are produced. If high enough quantities of beta emitting contaminants are allowed to remain on the skin for a prolonged period of time, they may cause skin injury. Beta emitting contaminants may be harmful if deposited internally.

- •**Gamma rays and x-rays).** They readily penetrate most materials and are sometimes called “penetrating” radiation. Thick layers of dense materials are needed to shield against gamma radiation. Protective clothing provides little shielding from gamma and x radiation, but will prevent contamination of the skin with the gamma emitting radioactive material. .

Radiation Units

- •A curie is a very large amount of radioactivity. Contamination of individuals usually involve μCi to mCi quantities. Nuclear medicine patients are injected with μCi to mCi quantities of radioactive material for routine diagnostic exams.
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- •The basic unit of radiation dose is the rad(radiation absorbed dose). The rad is defined as the deposition of 0.01 joule of energy (a small amount) per kilogram (kg) of tissue.

- •A rad of x-rays, a rad of gamma rays, and a rad of beta particles are about equally damaging to tissue. However, a rad of alpha particles or neutrons, is much more damaging to tissue than a rad of gamma rays.
- •The rem was introduced to take into account this variation in tissue damage. This is important because a person may be exposed to more than one type of radiation. For example, it was found that 100 rad of gamma and beta radiation produced the same effect as 100 rad of x-rays. However, only 20 rad of neutrons and 5 rad of alpha particles produced the same effect as 100 rad of x-rays.

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- •The International Scientific System (SI) assigns different units to the quantities:
- 1 gray (Gy) = 100 rad
- 1 sievert (Sv) = 100 rem

Radiation Doses and Dose Limits

- Radiation from the environment, as well as cosmic radiation from the sun and universe, makes up the natural background radiation to which we are constantly exposed. On the average, persons are exposed to about 300 millirem per year from natural sources.
- *Limitation of Exposure to Ionizing Radiation*,

  workers may approach or exceed 50,000 mrem to a large portion of the body.

- •If an individual is exposed to more than 100 rem at one time, predictable signs and symptoms will develop within a few hours, days, or weeks depending on the magnitude of the dose.
- About half of all people exposed to a single dose of 350 rem will die within 60 days (LD50/60) without medical intervention.
- The large doses used in medicine for radiation therapy, while higher than this dose, are given to only part of the body and are typically given over a period of weeks.

Half-Life

- •**The physical half-life** is the amount of time required for a given amount of radioactive material to be reduced to half the initial amount by radioactive decay.
- •**biological half-life** is the time required for the human body to eliminate half of the radioactive material taken into it. For many radioactive materials, the elimination from the body occurs via urination. However, depending on the chemical composition of the radioactive material, other pathways can also help to eliminate the radioactive material from the body.
- Both the physical half-life and the biological half-life contribute to the elimination of the radioactive material from the body. The combination of these two half-lives is called **the effective half-life**.

- •Radioactive materials emit ionizing radiation. They are used in medical diagnosis (nuclear medicine), medical therapy (cancer treatment), industry (food irradiation), and for research.

- •Half-lives can range from seconds to millions of years.

Reducing Radiation Exposure

- •There are three methods for reducing radiation exposure: time, distance, and shielding. All three of these methods can be used to keep radiation exposure to a minimum.
- Leaded aprons and thick lead walls are used to shield from the x-rays that are scattered from the patient undergoing an x-ray procedure.

Decontamination Center

- •A decontamination center should be established to monitor people who may be contaminated and provide facilities for decontamination.
- •Ideally, it should provide showers.
- •A decontamination center should be staffed by physicians with a radiological background, health physicists or other staff familiar with decontamination procedures and the use of radiation survey meters, and psychological counselors.
- •Towels and replacement clothing should be available.

Radiation Effects

- Deterministic effects; threshold dose + occur within one year

- Stochastic effects; no threshold dose + occur within many years(cancer)

Clinical presentation

- **. Radiation Sickness - Acute Radiation Syndrome** (ARS)] is an acute illness following exposure to a very large dose of ionizing radiation.
- •For doses of approximately 15 rem, the patient should be asymptomatic, but an increased number of chromosomal aberrations may be detectable in circulating lymphocytes.
- •For doses of approximately 50 rem, the patient should be asymptomatic, but show minor decreases in white cells and platelets.
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- The acute radiation syndrome occur in four distinct phases: prodromal (initial), latent period, manifest illness stage and recovery or death.

  -prodromal stage; NVD, abdominal camps

  - latent stage, improvement of symptoms

  -the manifest-illness stage; bone marrow suppression, sepsis and death

  - the recovery phase; hair loss, burns and scars

Treatment of ARS

- Treat patients symptomatically as they occur for nausea, vomiting, diarrhea, fatigue, electrolyte imbalance, and pancytopenia. Treatment should focus on prevention of infection. Antibiotics should be given to sterilize the gut and treat opportunistic infections.
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- •Hematopoietic growth factors should be given within the first 24 to 48 hours and then daily.

EX. OF Hematopoietic growth factor

- (Granulocyte-Macrophage Colony Stimulating Factor) GM-CSF works deep within the bone marrow to stimulate the cellular division and specialization of undifferentiated immune cells. GM-CSF, as its name conveys, binds to the specific cell receptor to promote the specialization of granulocyte and macrophage cells. During wound repair processes GM-CSF will activate the specialized function of immune cells to engulf toxins and kill damaged or abnormal cells.

Chronic Health Effects from Radiation

High radiation doses have been linked to a modest increase in the incidence of **cancer** in exposed populations, such as the atomic bomb survivors. At low doses, below about 20 rem, the potential for cancer causation is uncertain and generally believed to be quite small.

- Radiation's ability to produce **hereditary effects on children** e.g. malformations and genetic disease at 1-2 years of age is 6-10%.
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Fetal Irradiation

- •Termination of pregnancy is NOT justified based upon radiation risks for fetal doses less than 10 rem.
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- •Fetal doses greater than 50 rem can cause significant fetal damage
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Patient Management

- **Medical stabilization (ABC supportive therapy) takes priority over decontamination.**
- **Decontamination**

  Patient decontamination should be performed after stabilization of the patient. Removal of clothing usually occurs in the field, prior to transport to the hospital.

  If radioactive objects are recovered, they should be placed in a lead container using forceps and then placed at a distance from staff and patients.

  Cease decontamination of the skin and wounds when the area is less than twice the background reading on the survey meter.

Specific antidotes for enhanced elimination

Deposition of radioactive materials in the body (i.e., internal contamination), is time-dependent and can be quite rapid.

- •Several methods of preventing incorporation (e.g., catharsis, gastric lavage) might be applicable.

-prussian blue is used for cesium-137 (food irradiator)

- potassium iodide dilutes iodine-131(nuclear medicine therapy) and blocks thyroid iodine uptake.
- TPA(diethylenetriamine pentaacetic acid) for plotonium-239 (nuclear weapon).
- Aluminium hydroxide reduces absorption of

Strontium-90 (eye therapy device) or uranium-233, -235, -238 (nuclear weapon)